Appendix P

Memo Documenting Calculated Fixed Radius Methodology

CORRESPONDENCE/MEMORANDUM

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TO: Drinking Water and Groundwater Regional Experts

FROM: Mike Lemcke - DG/2

SUBJECT: CFR calculation methodology

The purpose of this memo is to document the methodology used in preparing calculated fixed-radius (CFR) delineations for vulnerability assessments and source water assessments of Wisconsin's municipal wells.

Background

Under Wisconsin Administrative Code NR 811.16(5), all municipal wells constructed after April 1, 1992 must have an approved wellhead protection (WHP) plan before going into service. Under Wisconsin's approved WHP plan the DNR is responsible for delineating WHP areas for all municipal wells in the state by the CFR method. However, it should be noted that municipalities are encouraged to perform more site-specific, detailed delineations and, if acceptable, these voluntary delineations will replace the DNR's delineations for that municipality.

The vulnerability assessment program also utilizes calculated fixed radii to delineate areas to inventory potential sources of contaminants. In 1995, CFRs were used for this purpose for vulnerability assessments for all municipal wells in the state.

The CFR calculation $r = [(Qt)/(\pi nH)]^{1/2}$ requires discharge (Q) during a period of time (t), aquifer porosity (n), and length of the open interval (H), to determine the radius (r) of a cylinder containing the volume of water discharged from the well in a chosen time period (see attached figure). At the ground surface, the radius can be used to delineate an area around the well to be used for wellhead protection. Wisconsin's WHP plan uses a five year time period to ensure adequate drinking water protection. If the CFR is less than 1200 feet, Wisconsin uses 1200 feet for the WHP/vulnerability assessment radius for the well.

1995 CFR Methodology

In 1995, the CFR method was used to calculate protection areas for municipal wells based on the wells' actual pump capacity obtained from the public water sanitary survey reports. In many cases, communities add new wells when existing wells discharge 50 percent of their capacity, therefore the 1995 CFR calculations were done using one-half of a well's pump capacity. Most of the state's wells (approximately 70%) had pump capacities recorded on sanitary surveys. For the remaining wells it was necessary to use either the approved pump capacity or the design pump capacity recorded on the well construction reports for estimates of discharge. Open interval lengths were determined by calculating the distance from the bottom of the casing to the bottom of the drill hole, or in the case of sand and gravel wells, the screen length itself. Aquifer porosity was estimated by using lithology obtained from the high capacity well database and calculating a weighted average based on lithological proportions of the open interval and standard porosity constants described in the *Wellhead Protection Program Plan* (Wisconsin DNR, 1993). If a radius was calculated to be less than 1200 feet, they it was automatically raised to the default 1200-foot minimum.

1998 CFR Methodology

In December 1997 the DNR began a project to update and automate the CFR determination process. One goal of this project is to have CFR delineations completed for all municipal wells in the state in time to be used for vulnerability assessments in the summer of 1998. Other-than-municipal community wells were also

considered for CFR calculations until it was realized that the relatively low pumping rates of those wells would result in radii of less than 1200 feet, and therefore default to a 1200 foot radius.

Creating CFR delineations began with an up-to-date listing of all non-permanently abandoned municipal wells in the region of study. These listings, obtained from extractions from the high capacity well and Public Water Supply (PWS) databases, include the name of both the water utility and the municipality, the well name (e.g., well #3), the well status (active, temporarily inactive, etc.), the Wisconsin Unique Well Number, and the PWS ID number. A spreadsheet macro was then created to include the water utility and/or municipality names, the well name, the Wisconsin Unique Well Number, and columns for monthly well discharge.

In updating the 1995 delineations it was decided to use discharge estimates that more accurately reflect actual pumping data. To evaluate how to do this, a random sample of pump capacity and actual discharge data from 30 municipal wells across Wisconsin was collected. Of these wells, 1997 pumping totals exceeded 50 percent of pump capacity for only 3 wells. On average, the actual discharge was 29 percent of the pump capacity. Additionally, the standard deviation of the percentage of pump capacity was 22 percentage points, indicating a wide range of pumping/pump capacity ratios. Based on this sample it was decided to use actual discharge based on pumping reports submitted to the Department under NR 811.05 for the 1998 CFR calculations. These reports list daily, total, and average discharge for each month.

To collect discharge information, 1997 pumping reports were consulted and the monthly discharges were summed for an annual total. For those wells having more than two months with zero reported discharge in 1997, monthly totals from 1996 or 1995 reports were used to fill in the missing information whenever the sum was greater than the 1997 total. Pumping data from 1996 reports were used to supplement South Central, Northeast and Southeast Regions. The 1996 reports were being microfilmed at the time the West Central and the Northern Region's delineations were calculated so 1995 data were used for those two regions. For wells having only one or two months of missing or zero data, missing discharge was estimated by averaging the remaining monthly discharge for that well. In cases with operational wells having only a few months of actual discharge for both 1997 and 1996 or 1995, or standby wells with no reported discharge or pumped for maintenance purposes only (e.g., hydrant flushing, pumping to wastewater, flow-meter calibration, etc.), or for new wells that went into service in 1997, annual discharge totals were obtained by averaging all other annual well discharge for that municipality.

Aquifer porosity was calculated as described above for the 1995 CFR delineations. Open interval lengths were also calculated as in 1995, with data obtained from the high capacity well database. In those instances where well construction data were incomplete, municipal sanitary surveys were reviewed. If neither of these two sources provided adequate information, the original well construction reports, in either hardcopy or digital format, were consulted for drillhole, casing, and geology information. Collected porosity and open-interval data were entered into a separate spreadsheet containing the same well identifiers as the pumping spreadsheet.

In cases where wells pump from unconsolidated material (glacial outwash or till), their screened length was recorded as the open interval. For Ranney wells (radial collectors), one-half the saturated interval (as determined by depth from static water table to radial collectors) was used as the open interval. In the case of blind-end wells (unscreened wells pumping from unconsolidated material), the depth of the gravel pack was used for the open interval.

As in 1995, if a radius was calculated to be less than 1200 feet, it was automatically raised to the default 1200-foot minimum.